Cadmium in sunflower seeds: different contents in hulls and kernels and consequences for food and feed industry

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Presentation outline

1. Context and objectives of the study
2. Materials and methods
3. Results and discussion

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1. Context and objectives of the study

Cadmium

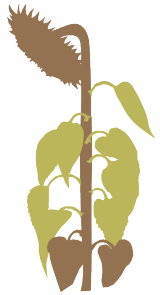
- A toxic metal
- Naturally present in soils
- Toxic to living organisms: carcinogenic, mutagenic and reprotoxic

Soil contamination

- Diffuse contamination in agricultural soils
- Mainly derived of soil pedogenesis
- Or coming from agricultural inputs (phosphoric fertilizer) or atmospheric fallouts

Contamination of food chain

- Cadmium absorption by plant root and transfer to the consumed parts of plants
- Consumers are exposed to cadmium through their diet
- An incresase in Cd in food (EAT1, EAT2) and in the impregnation of French population (Esteban and ANNS studies) between 2000 and 2009
- **Sunflower strongly transfer Cd from soil to seeds**
- **Cd concentrated in meal after crushing (very little in oil) ⇨ issue for animal feed (or for innovative uses in human food)**



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1. Context and objectives of the study

What are the regulatory thresholds for sunflower?

- **Food**: Commision regulation (EU) 2021/1323

Sunflower seeds used for human consumption should have Cd content **< 0,5 mg/kg**
This threshold does not apply to oilseeds intended for crushing, provided that the meal is not used for human consumption.

- **Feed**: Directive 2002/32/EC on undesirable substances in animal feed

Raw materials for animal feed (including sunflower seeds and meal) should have Cd content **< 1 mg/kg**

Cd contents found in the sunflower sector in France (PSO, 2015-2022):

- Sunflower seeds: 0,3-0,4 mg/kg (14% samples > 0,5 mg/kg and 0% >1 mg/kg)
- Sunflower meals: 0,5-0,6 mg/kg (1,5% samples > 1 mg/kg)

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1. Context and objectives of the study

Fate of Cadmium in crushing process with dehulling ?

Crushing industry

Oil (TAGs) for food and non-food uses

2 co-products

Meal for feed as protein-rich feedstuff

What we know: Cd is concentrated in the meal

Sunflower seeds composition: 2 main fractions

Kernels : oil and protein

70-80%

20-30%

Hulls: fiber rich

Hulls are richer or lower than kernels in Cd ?

Crushing industry with **partial dehulling** prior to crushing

Hulls: for energy

Partially dehulled seeds

Partially Dehulled Sunflower Meal (PDSM): higher content in protein

Oil

Higher content in Cd in this meal ?

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1. Context and objectives of the study

Objectives of the study:

- to study the repartition of Cd between hulls and kernels
- to evaluate the consequences for the Cd content in meals
- to evaluate the genetic variability for Cd repartition between hulls and kernels as a perspective for breeding

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2. Material and Methods

Sunflower seed sourcing

- Seeds collected in a field trial: 3 cultivars (ES Biba, Extrasol, Vellox)*3 replicates
- Cultivation: on a calcareous loam in Charente-Maritime County in France, this soil having a moderately high Cd content (1 mg Cd/kg), whereas the median Cd content of cultivated soils in France is 0.2 mg/kg.

Treatment on seeds

- Washing: Half of the samples was washed with distilled water ▭ in order to check if Cd content in seeds was affected by dust deposited onto hulls during harvest.
- Dehulling: Samples were dehulled on a pilot dehulling equipment: two fractions were separated ▭ kernels and hulls

Cadmium content determination

- The Cd contents in hulls and kernels were determined by atomic absorption spectroscopy after digestion in a HNO_3-HCl mixture.

3. Results and discussion

Characteristics and Cd content of the whole seeds

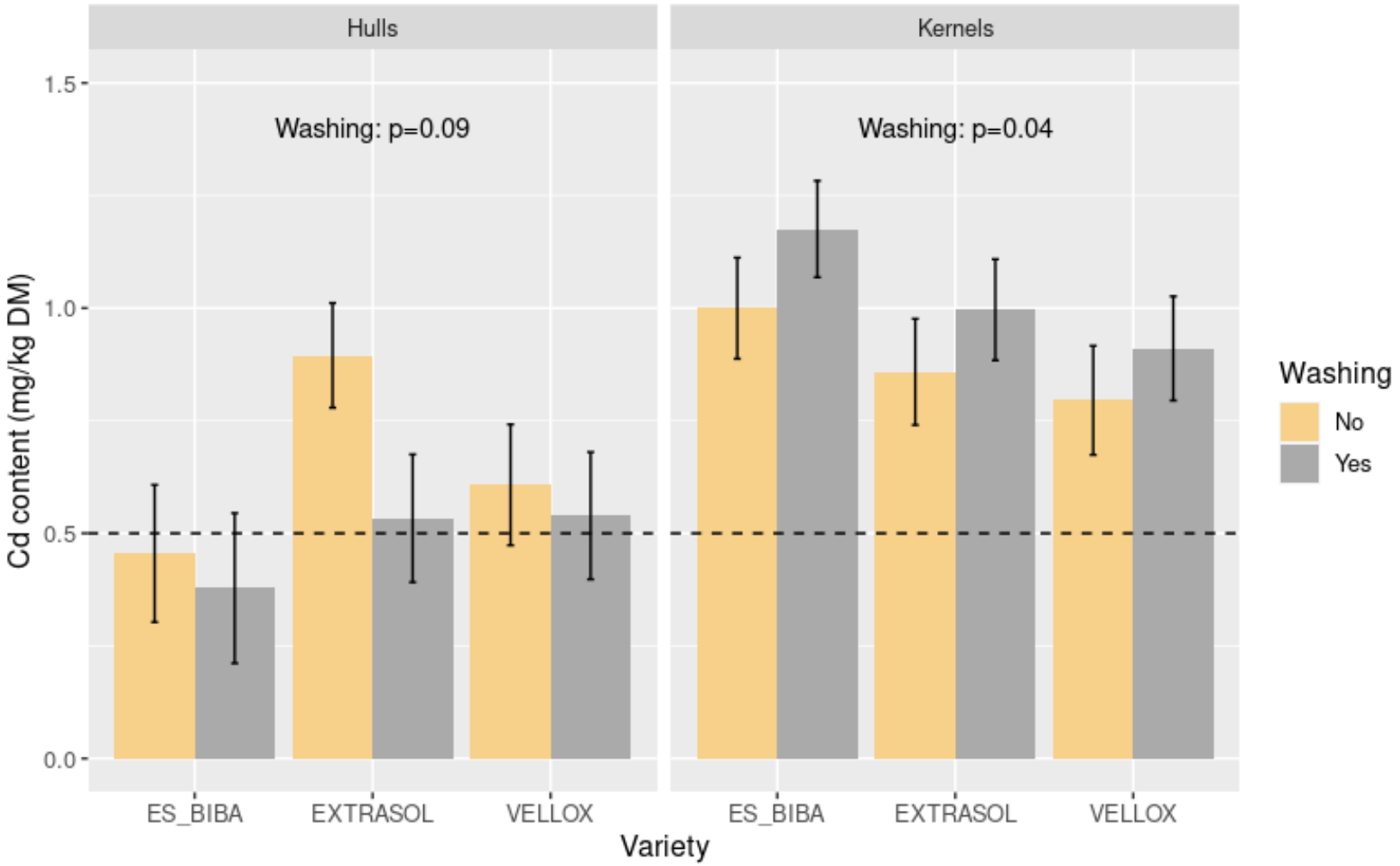
Mean value (Standard errors) N=3		Varieties			
		ES Biba	Extrasol	Vellox	
Thousand kernel weight (g DM)		56.1	58.7	54.5	
Whole seed oil content (% DM)		54.1	53.1	57.5	Significative differences
Kernel/hull dry matter ratio		2.52 a	2.71 ab	2.88 b	No significative differences
Cd content (mg/kg DM at 9% H2O)	No washing	0.84 (0.11)	0.88 (0.13)	0.76 (0.11)	No significative differences
	With washing	0.88 (0.12)	0.83 (0.11)	0.70 (0.11)	

→ No significant effect of the variety on Cd content of whole seed
→ No significant effect of washing on Cd content of whole seed

→ Cd content in seeds < feed regulatory limit but > food limit
This contamination is not representative of the average Cd level in sunflower seeds cultivated in France (specific soil with high Cd content due to geological substratum)

3. Results and discussion

Cd content in hulls and kernels



→ Weak effect of seed washing on Cd content of hulls and kernels

→ Kernels are more concentrated in Cd than hulls

- Cd ratio between kernels and hulls depends on variety:
  - ES BIBA x 2.6
  - Extrasol x 1.3
  - Vellox x 1.5

Hypothesis : link with size of kernel versus hull affects dilution of Cd in kernel

3. Results and discussion

Cd content in edible sunflower products

Mean value N=3	Varieties			
	ES Biba	Extrasol	Vellox	
Fraction of Cd in kernels (%)	87% a	78% b	82% b	Significative differences
Calculated Cd content of meals from whole seeds (without dehulling) (mg/kg DM)	1.74 a	1.65 b	1.55 b	No significative differences
Calculated Cd content of meals from dehulled seeds (67% hulls removed) (mg/kg DM)	2.43 a	2.05 b	2.17 b	Significative differences
Calculated Cd content of meals from kernels	3.41 a	2.61 b	2.84 b	Significative differences

→ Cd fraction in edible kernel differed significantly : 78% (Extrasol) to 87% (ES Biba)
→ Dehulling (which increase protein content of meal) results in increased Cd content
→ Prospects of using kernel meals as source of proteins for humans are hampered by Cd

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Conclusion / take-away messages

- **Sunflower kernels are richer in Cd than hulls**

- **Kernel/hull ratio may affect dilution of Cd in kernel**

- **Genetic variability for capacity of transfer of Cd from hull to kernel may exist**

⇨ This opens perspective of breeding sunflower genotypes that accumulates less Cd in kernel, to increase food/feed safety

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More details in scientific article:

Nguyen, C., Loison, JP., Motard, C. *et al.* Cadmium partitioning between hulls and kernels in three sunflower varieties: consequences for food/feed chain safety. *Environ Sci Pollut Res* **31**, 1674–1680 (2024).

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